INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR
Department of Electronics and Electrical Communication Engineering

End Spring Semester Examination 2013 Full Marks : 120
Subject name: Electromagnetic Engineering Time: 3Hrs
Subject No: EC21006

Answer all the questions
All questions carry equal marks.

1. (a) For a lossless medium for which the characteristic impedance $\eta = 60\pi$, relative permeability $\mu_r = 1$ and the magnetic field $\vec{H} = -0.1\cos(\omega t - z)\hat{a}_x + 0.5\sin(\omega t - z)\hat{a}_y \; A/m$, calculate the relative permittivity ε_r, ω, and the electric field $\vec{E}$. [12]

(b) Given the electric flux density $\vec{D} = (2y^2 + z)\hat{a}_x + 4xy\hat{a}_y + x\hat{a}_z \; C/m^2$, find

(i) The volume charge density at the point (- 1, 0, 3).
(ii) The flux through the cube defined by $0 \le x \le 1, 0 \le y \le 1, 0 \le z \le 1$.
(iii) The total charge enclosed by the cube. [8]

2. (a) For the circuit shown below in Fig. 1, the load $Z_L = 200 + j100\,\Omega$ is to be matched to a $40\,\Omega$ line using a lossless transmission line of characteristic impedance Z_1 and length l. Find l and Z_1. [12]

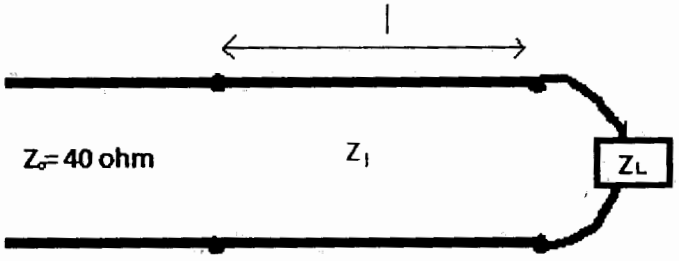

Fig. 1

(b) Find the input impedance Z_{in} of the following circuit : [8]

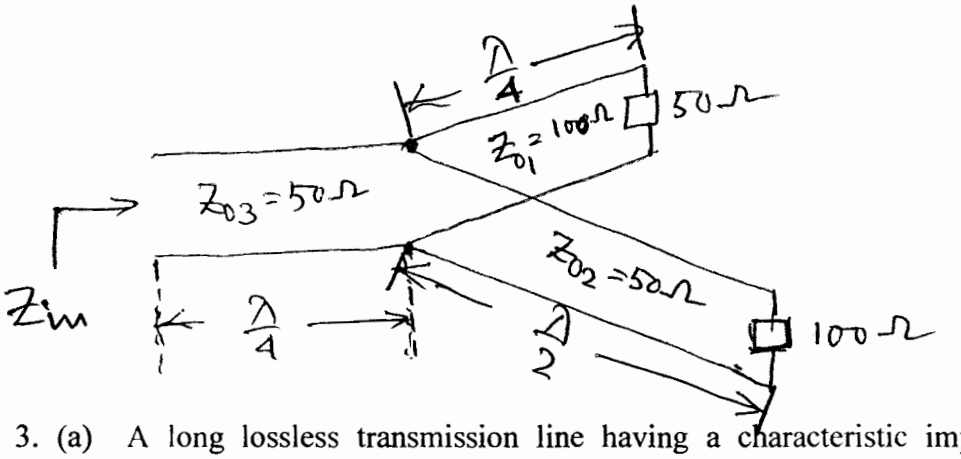

Fig 2

3. (a) A long lossless transmission line having a characteristic impedance of 50 Ω and terminated with a matched load is fed from a generator of internal resistance 1 Ω and open circuit voltage $V_g = 0.5 \cos(\pi \times 10^8 t)$ volts. The velocity of propagation on the line is 1.25×10^8 m/s. For the above configuration , find

(i) Input impedance seen by the generator. [4]
(ii) The voltage and current at the transmission line input. [4]
(iii) The instantaneous voltage and current at an arbitrary location 'x' along the line from the transmission line input. [4]

(b) The characteristic impedance of a uniform transmission line is 2040 Ω at a frequency of 800 Hz, with a propagation constant of $0.0054 \angle 87.9°$/m. Determine the per unit resistance, conductance, inductance and capacitance of the line. [8]

4. A long lossless line with characteristic impedance $Z_O = 50\ \Omega$ and operating at 1 GHz is terminated by a load impedance of $75 + j100\ \Omega$. Assuming the speed of propagation on the line to be $c = 3 \times 10^8\ m/s$, find

(i) The reflection coefficient at the load. [2]
(ii) The reflection coefficient at a distance of 20 m from the load. [5]
(iii) The input impedance at 20 m from the load. [5]
(iv) The standing wave ratio on the line. [2]
(v) The locations of the first voltage minimum and the first voltage maximum from the load. [6]

5. An antenna operates at a wavelength of 2 m and is designed with an impedance of 75Ω. However, because of mistakes in design, the antenna is badly mismatched. The measured impedance after installation is 15 + j60 Ω. The antenna is connected to a 75Ω line as shown in Fig. 3. Calculate

(a) The required shorted stub and its location on the line to match the antenna to the line, assuming the line and the stub to have the same characteristic impedance. [15]

(b) The shortest lengths of open circuit stub that will accomplish the same purpose as the short circuit stub in (a). [5]

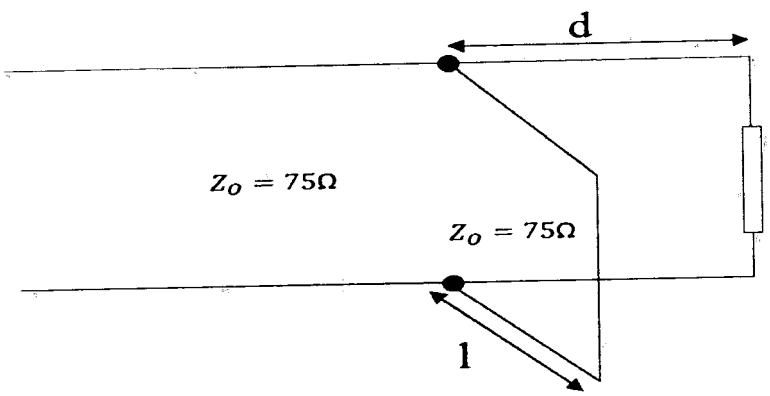

Fig. 3

6. (a) For the circuit configuration shown in the figure below (Fig. 4), find the location of the transformer (distance d in the figure) and the characteristic impedance of the transformer Z_t, with Z_L= 50 + j50, assuming the characteristic impedance of quarter-wavelength transformer to be real. [14]

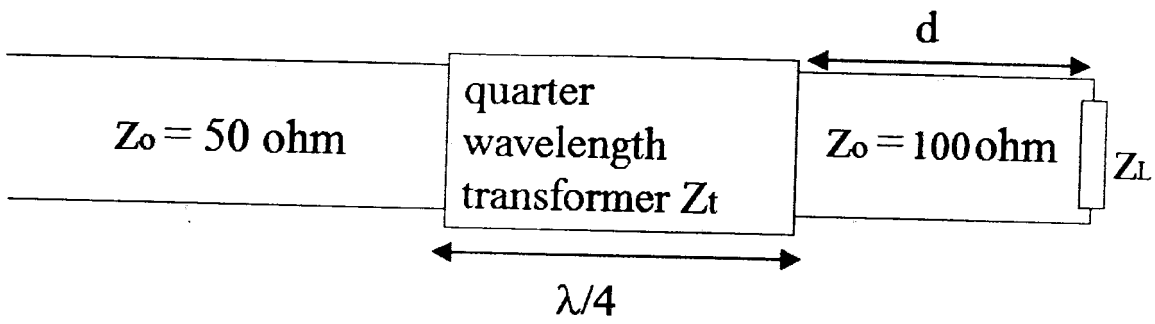

Fig. 4

b) For the given transmission line parameters R= 1.675 Ω/m, L= 0.592 μH/m, C=75 pF/m and G= 2.12 x 10^{-4} mho/m, find the following at frequency 1GHz :

(i) Propagation constant.

(ii) Phase velocity.

(iii) Characteristic impedance. [2x3=6]

The Complete Smith Chart

Black Magic Design